

NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

December 23, 2016

Cockpit Displays – Recorded Flight Data

Specialist's Factual Report
By Charles Cates

1. EVENT SUMMARY

Location: Marion, Illinois
Date: June 10, 2016
Aircraft: Cirrus SR22
Registration: N508AJ
Operator: Private
NTSB Number: CEN16FA214

On June 10, 2016, at 1634 central daylight time, a Cirrus Design Corporation SR22 single-engine airplane, N508AJ, impacted terrain following a loss of control during a simulated engine failure maneuver at the Williamson County Regional Airport (MWA), Marion, Illinois. The private pilot sustained fatal injuries, the flight instructor sustained serious injuries, and the airplane sustained substantial damage. The airplane was registered to and operated by AJ Air, Inc, Carbondale, Illinois, as a Title 14 *Code of Federal Regulations* (CFR) Part 91 instructional flight. Visual meteorological conditions prevailed at the time of the accident and a flight plan was not filed. The local flight departed MWA at 1605.

2. RECORDED FLIGHT DATA GROUP

A recorded flight data group was not convened.

3. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following electronic devices:

Recorder Manufacturer/Model: **Avidyne PFD**
Recorder Serial Number: **21638354**

Recorder Manufacturer/Model: **Avidyne MFD CF Card**
Recorder Serial Number: **N/A**

Recorder Manufacturer/Model: **Garmin D2 Watch**
Recorder Serial Number: **3E0001819**

3.1. Avidyne Primary Flight Display (PFD) Description

The PFD unit includes a solid state Air Data and Attitude Heading Reference System (ADAHRS) and displays aircraft parameter data including altitude, airspeed, attitude, vertical speed, and heading. The PFD unit has external pitot/static inputs for altitude, airspeed, and vertical speed information. Each PFD contains two flash memory devices mounted on a riser card. The flash memory stores information the PFD unit uses to generate the various PFD displays. Additionally, the PFD has a data logging function, which is used by the manufacturer for maintenance and diagnostics. Maintenance and diagnostic information recording consists of system information, event data and flight data.

The PFD samples and stores several data streams in a sequential fashion; when the recording limit of the PFD is reached, the oldest record is dropped and a new record is added. Data from the Attitude/Heading Reference System (AHRS) is recorded at a rate of 5 Hz. Air data information such as pressure altitude, indicated airspeed, and vertical speed are recorded at 1 Hz. Global Positioning System (GPS) and navigation display and setting data are recorded at a rate of 0.25 Hz, and information about pilot settings of heading, altitude, and vertical speed references are recorded when changes are made.

3.1.1. PFD Data Recovery

The recorder was damaged in the event. Damaged areas included the screen, case, and connector pins. The extent of the damage is shown in figure 1. The data were extracted from the unit using NTSB surrogate hardware.

Figure 1. Damaged exterior Avidyne PFD from N508AJ.



3.1.2. PFD Data Description

The PFD recording contained records of 47 power cycles and approximately 25 hours of data. The accident flight was associated with the 43rd power cycle¹. The duration of the 43rd power cycle was approximately 35 minutes. Timing of the PFD data is measured in seconds from power-on.

3.1.3. PFD Engineering Units Conversions

Conversion of the PFD data from the raw recorded information to engineering units is performed by NTSB data extraction software using information from the manufacturer.

Where applicable, changes to the conversions have been made to ensure the parameters conform to the Safety Board's standard sign convention that climbing right turns are positive (CRT=+).²

APPENDIX A lists the PFD parameters verified and provided in this report.

3.2. Avidyne Multi-Function Display (MFD) Description

The MFD unit is able to display the pilot checklist, terrain/map information, approach chart information and other aircraft/operational information depending on the specific configuration and options that are installed. One of the options available is a display of comprehensive engine monitoring and performance data.

Each MFD contains a compact flash (CF) memory card located in a slot on the side of the unit. This memory card contains all of the software that the MFD needs to operate. Additionally, this card contains all of the checklist, approach charts, and map information that the unit uses to generate the various cockpit displays.

During operation, the MFD display receives information from several other units that are installed on the aircraft. Specifically, the MFD receives GPS position, time and track data from the aircraft's GPS receiver. The MFD may also receive information from the aircraft concerning altitude, engine and electrical system parameters, and outside air temperature. This data is also stored on the unit's CF memory card.

The MFD generates new data files for each MFD power-on cycle. The oldest file is dropped and replaced by a new recording once the storage limit has been reached. MFD data are sampled every six seconds, and are recorded to memory once every minute. If an interruption of power occurs during the minute between MFD memory write cycles, data sampled during that portion of a minute are not recorded.

¹ During the normal data retrieval process, power is applied to the PFD. Therefore the accident data is not necessarily the last power cycle recorded.

² CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Left Aileron Trailing Edge Down = -, Right Aileron Trailing Edge Up = +, Pitch Up = +, Elevator Trailing Edge Up = +.

3.2.1. MFD Data Recovery

The MFD CF data card was in good condition and the data were downloaded using the manufacturer's procedure and NTSB surrogate hardware.

Figure 2. Compact Flash Card Found in Avidyne MFD from N508AJ.



3.2.2. MFD Data Description

The MFD CF card contained 220 data files corresponding to 110 flights. One data file was identified as recording during the incident flight. The data file was approximately 35 minutes in duration.

3.2.3. MFD Engineering Units Conversions

The data files downloaded from the MFD are in engineering units.

Appendix A APPENDIX A lists the MFD parameters verified and provided in this report.

3.3. Garmin D2 Watch Description

The Garmin D2 Watch is a wrist-worn GPS computer with many of the capabilities of panel-mounted GPS devices. Capabilities include standard watch functions including time, date, alarm and timer, along with aviation GPS features including a barometric altimeter, electronic compass, and a worldwide airport database. The watch can connect with Bluetooth devices to receive flight plans and waypoints and then be used as a navigation aid.

3.3.1. Garmin D2 Watch Data Recovery

The watch was in good condition aside from a broken band. It was received with the battery in a discharged state. It was connected to a charging and docking cable, charged, and

powered up normally. The memory was read out using the manufacturer's software and procedure. No track logs or other data relevant to the crash were recorded on the device.

Figure 3. Damaged exterior of Garmin D2 Watch.



3.4. Time Correlation

Correlation of the PFD data to central daylight time (CDT) was established using the recorded GPS time parameter from the PFD data. Recorded GPS time is updated in 6 second intervals on the PFD³. The GPS time is recorded in Universal Coordinated Time (UTC). The difference between CDT and UTC is 5 hours, or 18,000 seconds. The PFD starts recording when power is applied to the unit. Each power cycle the timing begins at 0 seconds and the PFD data is measured in seconds from power-on. An offset is applied to each power cycle plotted to display the data with the local time zone. Therefore, for the rest of this report, all times are referenced as CDT, not recorded time.

3.5. Plots and Corresponding Tabular Data

The following six figures contain data recorded during the June 10, 2016 event.

Figures 4 and 5 contain basic aircraft data recorded by the PFD. Figure 4 is from the full duration of the flight, about 16:05 CDT to 16:33 CDT. Figure 5 shows the final touch and go to the end of the recording, from about 16:25 CDT to 16:33 CDT.

Figures 6 and 7 contain engine data recorded by the MFD, and show the same time periods as figures 4 and 5, respectively.

³ GPS information is recorded at 4 second (0.25 Hz) intervals; however it is possible to have the same UTC time recorded in consecutive GPS data records due to the 6 second update rate of the GPS time parameter.

Figures 8 and 9 are a map overlay using Google Earth of the GPS position data recorded in the PFD. Note that the atmospheric and lighting conditions in Google Earth are not necessarily representative of the conditions at the time of the event. Figure 8 shows the full recording of the event flight, and figure 9 highlights data recorded during the final minute of the recording.

Figure 4 shows that prior to the event, the aircraft performed a total of six touch and go maneuvers using a left turning pattern. For all but the last, the aircraft climbed to about 1,500 ft before descending back to the airport. Aircraft roll during the left turns typically reached between 30-40 degrees.

Figure 5 shows that for the final touch and go, the aircraft touched down at about 16:27:05, and pitched up to depart at about 16:27:17 CDT. Following the final touch and go, the aircraft climbed to about 3,000 ft, circling in a manner that kept the aircraft in the vicinity of the airport. As the aircraft descended, airspeed gradually decreased from about 110 kts to about 87 kts. In the final three seconds, vertical, lateral, and longitudinal accelerations all increased to recorded peaks of 1.4g, -0.2g, and 0.4g, respectively. Roll increased in the final second of the recording from 36 degrees left to 45 degrees left. Pitch during this time ranged from -0.5 degrees to 2.4 degrees.

Figure 6 shows that engine parameters varied during the recording from values similar to those typically seen at takeoff to reduced power settings similar to those seen at engine idle during descent.

Figure 7 shows that at about 16:27 CDT the engine began to accelerate following the final recorded touch and go. The engine stayed at a steady power setting as the aircraft climbed to about 3,000 ft. At the top of the climb, engine power reduced slightly for about 30 seconds, then reduced to an idle setting for the remainder of the recording. The engine parameters recorded by the MFD ended before the PFD parameters because of the MFD memory write cycle described in Section 3.2 of this report.

Figures 8 and 9 show that the aircraft stayed in the pattern area of the airport. During the final approach, the airplane was at 1,323 ft as it crossed the runway threshold. It then made a tight descending left turn of nearly 360 degrees when the data ended.

The corresponding tabular data used to create these six plots and overlays are provided in electronic (*.csv⁴) format as Attachment 1 to this report.

⁴ Comma Separated Value format.

Figure 4. Plot of basic parameters during entire flight.

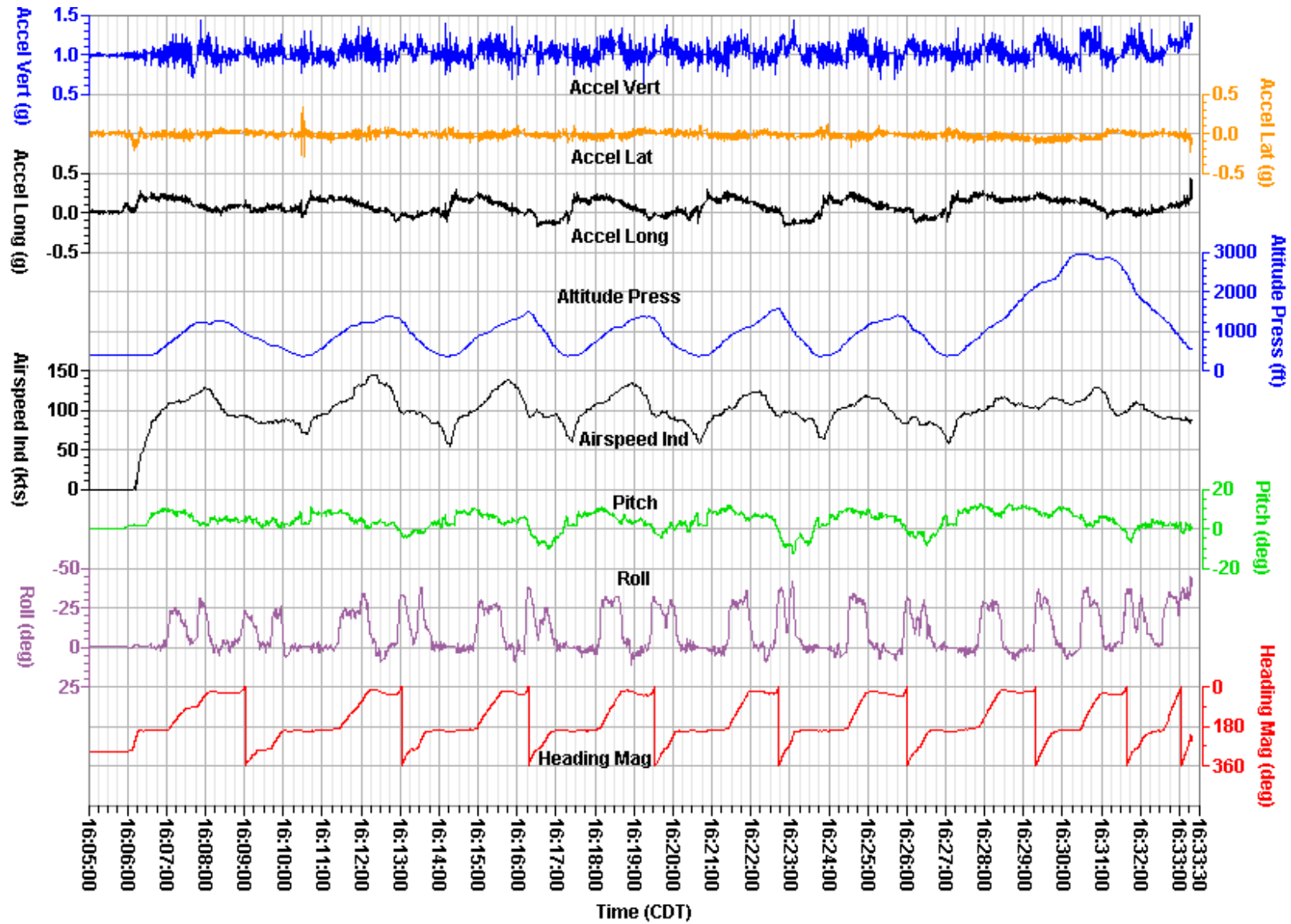


Figure 5. Basic parameters from final touch and go to end of recording.

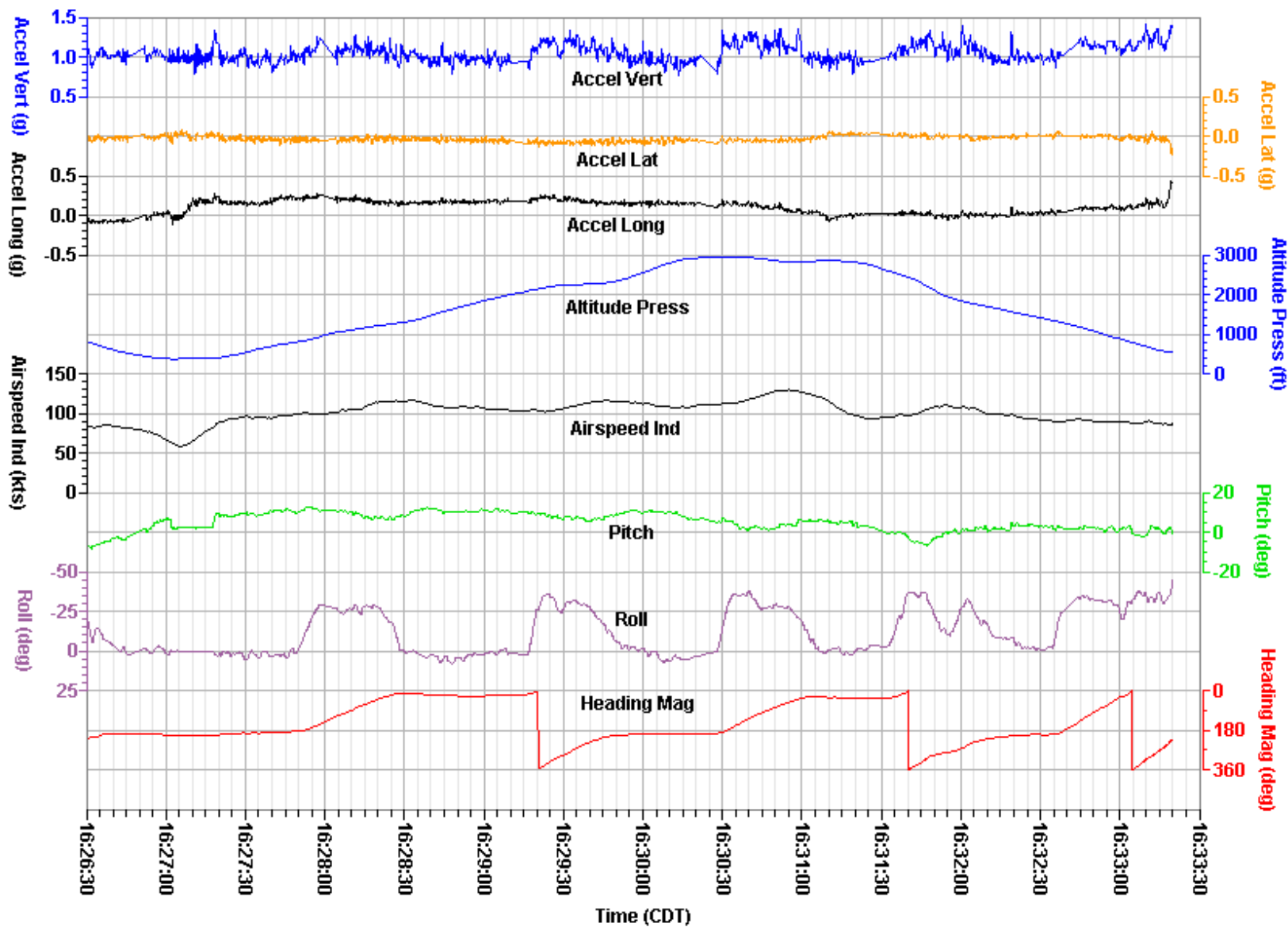


Figure 6. Engine parameters from entire flight.

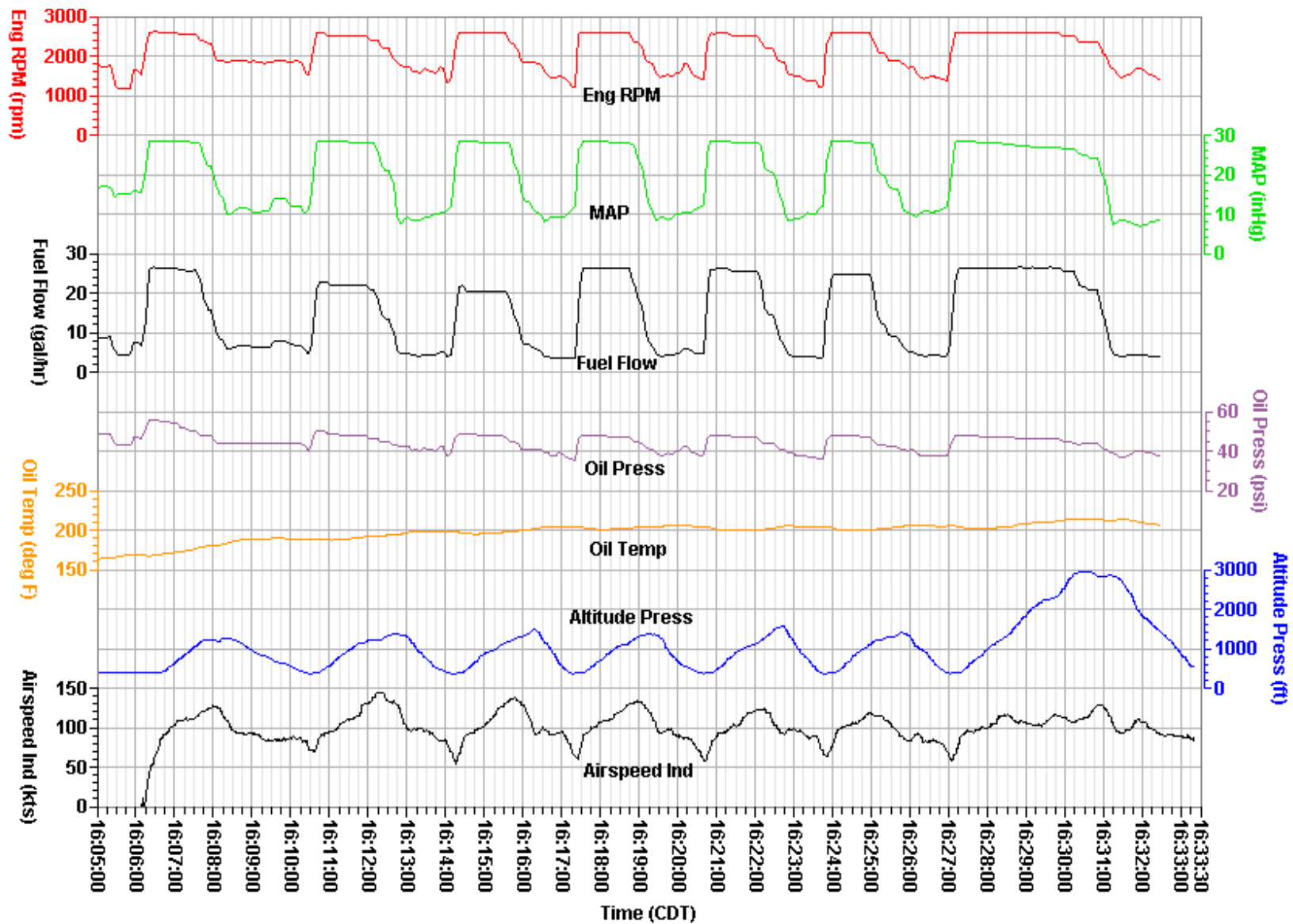


Figure 7. Engine parameters from final touch and go to end of recording.

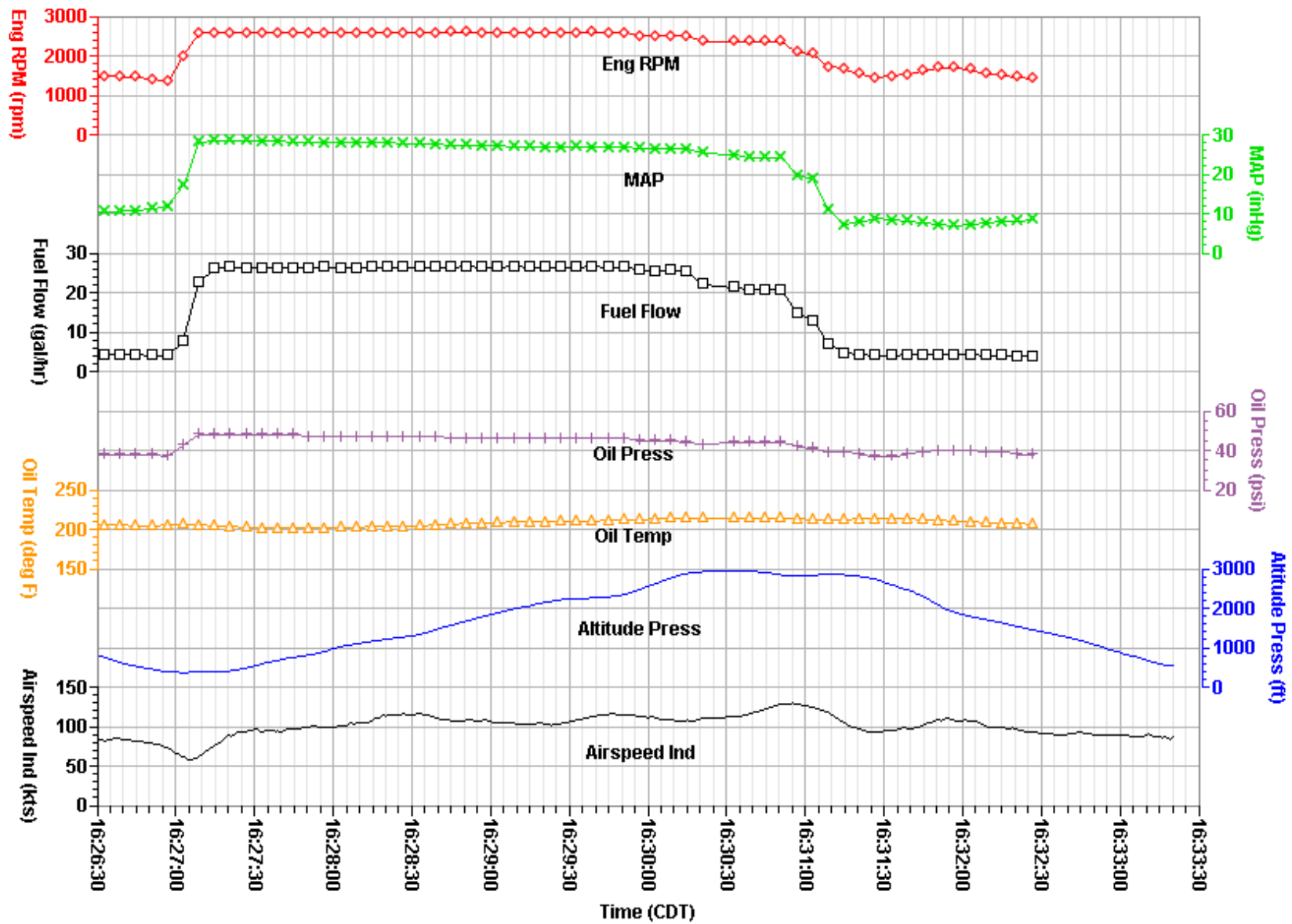


Figure 8. Map overlay of position data from full flight.

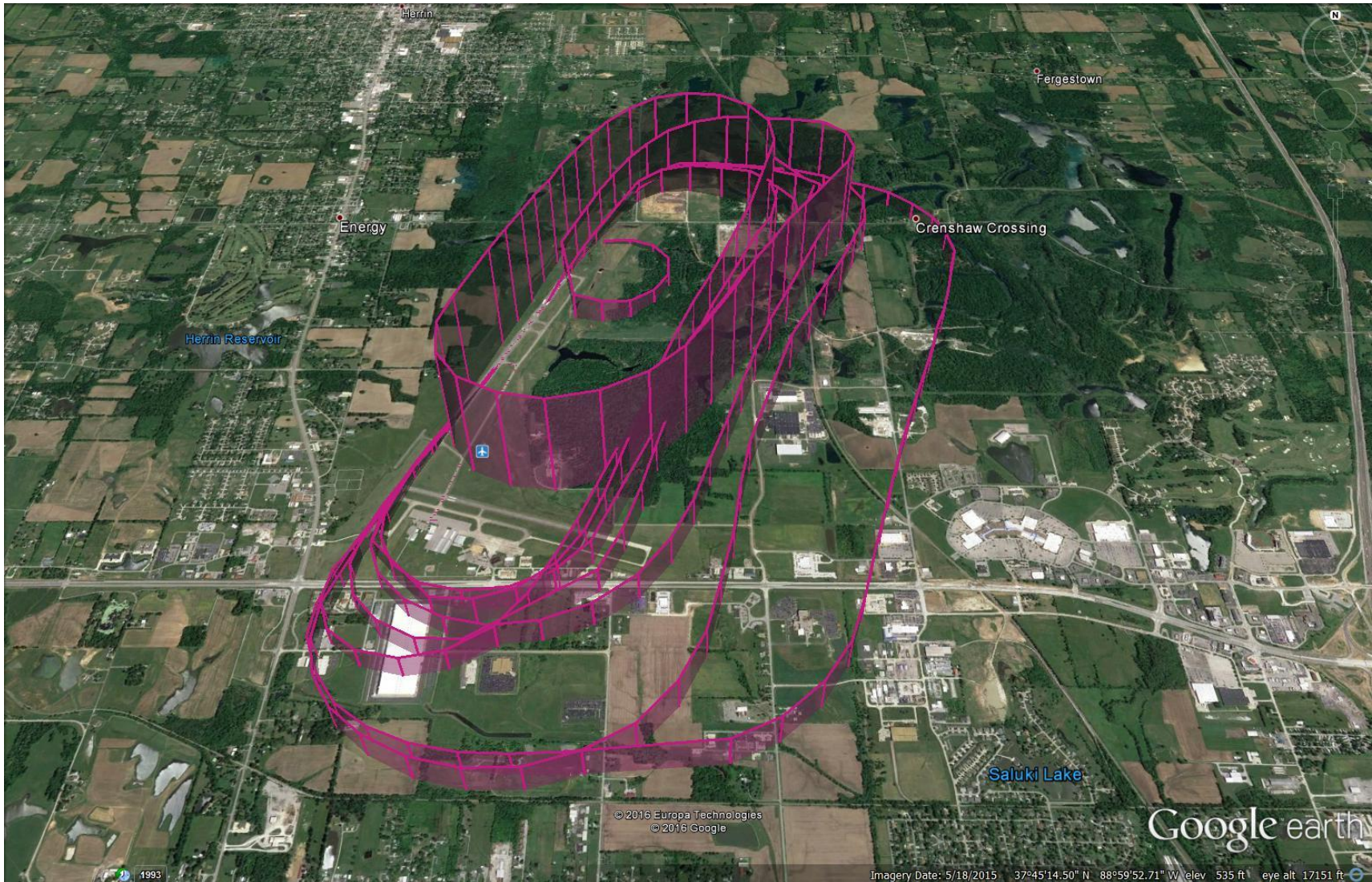
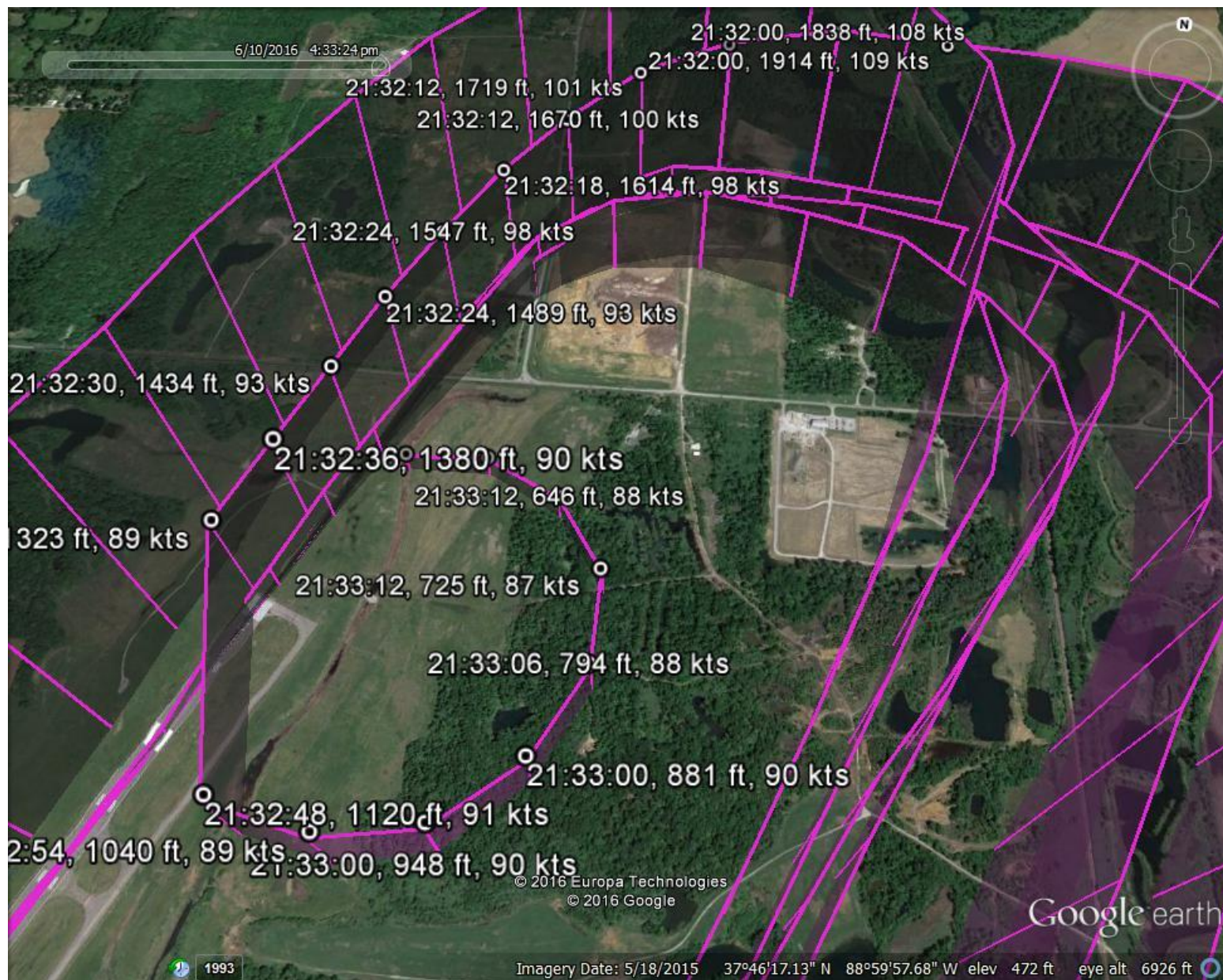


Figure 9. Map overlay highlighting final minute of recorded data.



APPENDIX A – PFD and MFD Parameters

This appendix describes the parameters provided and verified in this report. Table A-1 lists the PFD and MFD parameters and table A-2 describes the unit abbreviations used in this report for PFD and MFD parameters.

Table A-1 - Verified and provided parameters.

Parmeter Name	Parameter Description	Source
1. Accel Lat (g)	Lateral Acceleration	PFD
2. Accel Long (g)	Longitudinal Acceleration	PFD
3. Accel Vert (g)	Vertical Acceleration	PFD
4. Airspeed Ind (kts)	Indicated Airspeed	PFD
5. Altitude Press (ft)	Pressure Altitude	PFD
6. Eng RPM (rpm)	Engine RPM	MFD
7. Fuel Flow (gal/hr)	Fuel Flow	MFD
8. Heading Mag (deg)	Magnetic Heading	PFD
9. Latitude (deg)	Latitude	Both
10. Longitude (deg)	Longitude	Both
11. MAP (inHg)	Engine Manifold Pressure	MFD
12. Oil Press (psi)	Engine Oil Pressure	MFD
13. Oil Temp (deg F)	Engine Oil Temperature	MFD
14. Pitch (deg)	Aircraft Pitch	PFD
15. Roll (deg)	Aircraft Roll	PFD

The PFD records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event.

Table A-2 - Unit abbreviations.

Units Abbreviation	Description
kts	knots
ft	feet
rpm	revolutions per minute
gal/hr	gallons per hour
deg	degrees
inHg	inches of Mercury
psi	pounds per square inch
deg F	degrees Fahrenheit